Country Club Lawn and Tree Specialists Inc.

Operation and Safety Manual

Contents

System Capabilities

Features Overview

Hylio AgroDrones contain an array of features to both enhance safety and assure its ability to effectively conduct the mission. Among these features are:

Rotor Fail Protection - If one rotor fails, the flight controller will compensate for the lost rotor and immediately travel to a safe land point. The flight controller will notify the operator via on-screen warnings as it returns to land. The aircraft will maintain stability, allowing the flight controller to safely land, or the operator to take control and manually land. This feature does not work on quadcopters and therefore is not available for the AG-110.

Ground Control Software System – All AgroDrone owners use a UAS ground control software system known as Hylio AgroSol. Hylio Inc. developed AgroSol for the express purpose of controlling Hylio Inc. agricultural drones. AgroSol has been used for ground station control of all recorded flight hours on the AgroDrone series.

Return-To-Launch (RTL) - The operator has access to an RTL command which they can use to instantly stop the UAS and return it to the set landing point at a predetermined, safe altitude.

Land - In the event that the primary and all backup land points have been compromised, the UAS can be autonomously landed in any other safe location. This can be completed using the ground control software without requiring manual RC control.

Emergency Pause - The operator has systems that can be used to instantly stop the UA during the mission, where the drone will pause and hover in place, awaiting further commands. It can then be manually moved to a new location, and forced to land at the alternate safe landing location, or return to launch for landing.

Geofencing - The UAS's flight controller is given GPS coordinates of a boundary that it cannot leave, keeping the UAS from leaving the pre-determined and defined operations area. When enabled, the UAS can "hit" the perimeter, but not fly past or through it. Manual or automatic inputs commanding the UAS to break the geofence are ignored. In the event the geofence is broken, the UAS will automatically enter RTL mode and return home to land.

Beacon - In the extremely unlikely event of a system malfunction that causes a crash, a beacon attached to the UAS will help the PIC and ground crew quickly locate it, ensuring a quick response to secure the equipment and surrounding area.

Redundant GPS - All UAS are equipped with redundant GPS units. Should the primary GPS unit experience a failure, the second GPS unit will automatically takeover as a failsafe to ensure accurate positioning and navigation is maintained. During regular operation, the GPS signals are blended to improve position accuracy. The system offers full redundancy of GPS (2), IMU (3), and Compass (3). If one or multiple units fail, the controller will switch in real-time between the redundant compass, IMU, and GPS.

Telemetry - Should a telemetry link to the base station be lost, the UAS has all mission parameters stored onboard, and can safely continue to execute a mission. The UAS will automatically return to land with or without telemetry link when the tank or batteries are low. The base station computer will alert the PIC when telemetry communication is lost, and the UAS will automatically RTL after 10 sections of sustained lost link, the PIC may also interrupt the RTL and bring the UAS back under RC control.

RC control - All missions occur with pre-programmed commands providing instructions to the UAS. At all times the PIC has an RC remote located near the ground control station, with the ability to override the current mission. If the AgroDrone detects that the RC connection is lost, the autopilot software will immediately end the mission and RTL. However, if the RC is powered off before the drone initiates the auto mission, the auto mission will continue. When the RC is turned on in this case, it will immediately take over control.

Emergency Kill Switch - An emergency "Kill Switch" allows the operator to instantly stop motors in the event of an emergency. This kill switch is available through the ground control computer telemetry link (RFD-AgroSol).

Full Black Box Recording of All Flights - Flight data shows time stamped information of all operator control input, GPS statuses and outputs, vibrations, battery voltage, accessory voltages, IMU outputs, compass readings and all other sensor and flight information. All flight information is automatically saved internally on the UAS. Any operator or system caused issues can be easily identified with this information. Hylio's ground control software offers analysis of this log information to help predict potential future problems. As a supplement to routine maintenance, these logs are analyzed daily to help protect the user from unforeseen issues.

Obstacle Detection and Avoidance - Hylio AgroDrones use two radars facing forward and back to detect obstacles around the drone. To ensure operational safety, this feature is optional and can be turned on/off in AgroSol. More details on this feature are included later in this document.

Safety parameters - Max altitude, distance from home, horizontal speed and vertical speed defaults are set by Hylio Inc. AgroDrones use multiple sensor types to ensure maximum altitude is respected in the event of primary altimeter sensor failure.

Aviation Lighting - All AgroDrones come with mounted navigation lights in a standard configuration to indicate orientation and health. The back LEDs are white. Front right: green. Front left: red. These LED lights are mounted underneath each motor. Hylio offers optional Long-range visible, high intensity LED strobes (not included by default).

Intelligent Assisted Launch and Landing - AgroDrones use GPS and IMU data to determine when the craft is fully on the ground, meaning the craft will not shut rotors off until firmly on the ground. Aircraft also uses IMU data to safely and smoothly handle "In Ground Effect" caused by the rotor downwash, which lessens stress and accident likelihood for operator.

Flight Stall Prevention - The flight controller prevents accidental 'throttle zero' motor stall while in the air. In an emergency, the operator can use the ground control station computer over the telemetry link to immediately kill all motors.

5-second auto-lock rotors - This feature automatically locks rotors from rotating for 5 seconds after the battery power is connected and again five seconds after rotors stop on land.

Change of Flight Parameters - Ability to change certain parameters in real-time (during flight).

Flight Controller Modifications - AgroDrone operators have the ability to program, calibrate, debug, and modify flight controller information without power to rotors: allows safe physical interaction with UAS while performing maintenance and servicing.

GPS Signals - For UAS operations where GPS signal is necessary to safely operate the aircraft, the PIC must immediately recover/land the UAS upon loss of GPS signal. Without a GPS signal, the drone is unable to maintain its location within the fenced spray location. If the UAS experiences a loss of GPS signal, the UAS immediately enters land mode, unless the PIC takes over manual control.

Altitude Sensing Redundancies - Hylio AgroDrones use 3 different sensors to determine altitude. Radar, barometer, and GPS. The radar is the primary source of altitude. If the radar fails, the drone will automatically RTL using barometer altitudes. If the radar fails, the Geofence will also be maintained using the barometer altitude to ensure the UAS does not exit the geofenced area.

Lost Link - If the PIC loses command or control link for a designated length of time, the aircraft will follow a predetermined route to finish the mission, reestablish link, or immediately return to land if the first two options are not possible. The UAS will automatically return when for low battery, or fluid in the tank, even when the link is lost. To ensure operational safety, this feature is optional and can be turned on/off in AgroSol. All safety features including automatic obstacle detection and avoidance remain in effect in the event of a lost link.

Operational Analysis - The AgroDrone flight controller firmware automatically logs flight hours on the UAS. These flight hours are tracked and displayed in AgroSol. This automatic flight hour tracking is used to ensure strict adherence to maintenance procedures.

Lost Link Failsafe

Activation Criteria

- The lost link failsafe can be turned on and off in AgroSol.
- When it is turned on, the failsafe will activate when there is a complete loss of connection with the ground control station via the telemetry link for a sustained 10 seconds.

Activation Actions

- Upon Lost Link Failsafe activation, the drone immediately enters RTL mode.
- When the drone enters RTL mode, Land mode, Pause mode, or any other failsafe mode: The pump immediately turns off.
- In RTL mode, the drone first climbs to the predetermined RTL altitude, then proceeds directly to the designated safe landing point and lands.
- When connection is regained with the ground station, the drone will not return to continue the mission. The drone will continue on to RTL and land, unless another command is sent.

Recommended Conditions to Enable/Disable

- Lost link failsafe is ALWAYS recommended to enable if the mission is possible to complete with this failsafe enabled.
- Only disable this failsafe if it can be confirmed that the airspace will be clear throughout the flight. Use a visual observer who is carrying the RC if possible.

Fly-Away Prevention

History

The Fly-Away has been a common problem with commercial UAS brands since their early adoption, particularly DJI. In 20,000+ flights across all Hylio UAS from 2015-2021, no Hylio Inc. Drone has ever experienced a Fly-Away event.

Prevention Measures

Hylio UAS are assembled in the USA of the highest quality components from across the world, and go through an intensive QA process before delivery. All Hylio missions are geo-fenced and saved internally on the UAS, to ensure there is no possibility of a Fly-Away in the event of a communications hardware failure. Hylio AgroSol reads back each mission after it is uploaded to confirm there was no mission data corruption during transmission. These steps ensure the UAS only follow missions as intended by the operator.

Fly-Away Procedures

Given the prevention measures above, the only cause for a Fly-Away would be a GPS system failure of both the primary and secondary GPS. In the event of such a failure, the drone immediately enters land mode. Given that the drone is no longer capable determining its location to maintain the integrity of its geofence, it was determined that an emergency land in the current location would be the safest course of action.

Obstacle Avoidance

Activation Criteria

- The front and rear radars constantly search for obstacles around the drone. The radars track and monitor objects within 30 yards of the UAS. Once a tracked obstacle comes within the designated avoid-radius of the UAS, avoidance action is initiated. The minimum allowable avoid-radius value is 5 yards.

Activation Actions

- If the drone sees an obstacle beyond the avoid radius, then it will slow down enough so that it will be able to stop before coming within that radius distance to the obstacle. It will continue following the mission but will slow enough to ensure it can stop in time to maintain the minimum obstacle distance.
- When the drone confronts an obstacle within the avoid radius, it will stop in place. If in an auto mission the drone will wait for further command. If it is in manual flight mode the drone will not allow you to fly closer than the OA radius set distance. The avoid-radius can be set in the drone settings on the planning tab.

Conditions to Enable/Disable

- Obstacle Avoidance is ALWAYS recommended to enable if the mission is possible to complete with this failsafe enabled.
- It may increase operational safety to disable obstacle avoidance only when a crop being treated gives many false obstacle positives. This can sometimes happen with very uneven crop heights. This can greatly reduce efficiency and increase risk by causing the drone to frequently deviate from its predetermined flight plan. First, attempt to increase the spray altitude to reduce false positives. If false positives continue, you may disable avoidance.
- Only disable this failsafe if it can be confirmed that the airspace will be clear throughout the flight. Use a visual observer who is carrying the RC if possible.
- The PIC must understand that without enabling obstacle avoidance, the drone may collide with any obstacle in the mission area. The mission area must be THOROUGHLY surveyed for potential obstacles before proceeding with avoidance disabled.

Capability

- The obstacle avoidance radars in an ideal setting can sense objects as small as 2mm in diameter. This performance will change depending on the obstacle and setting in question.
- The radars face forward and back and have a limited field of vision. They cannot see obstacles immediately to the left and right of the drone. Due to the limited vertical field of vision, it is possible for an obstacle to stick up from the ground or drop down from above and not be seen by the radars.
- Obstacle avoidance must be looked at as an airbag in case of an emergency. All missions should be planned properly to avoid incidents before taking off, instead of relying on the obstacle avoidance.
- It is important to understand that obstacle avoidance is not foolproof. Obstacle avoidance should not be “Tested” by the end user. Hopefully the end user will never put themselves in a position to test the obstacle avoidance.

System Operation

Spray Mission Workflow

Step 1: Survey

1. Travel to mission area before scheduled application.
2. Locate all fields to be treated.
3. Survey fields for dangerous topography, obstacles, nearby residences, and any other criteria that may disqualify a field for UAS application.
4. Use GPS Tracker to safely mark flags and obstacles on all application areas. (This step not required if field is previously marked or an imported shapefile is deemed safe).
5. Confirm that all obstacles within the application area are safely marked.
6. Determine chemical and rate for application on these properties.

Step 2: Pre-Mission Preparation

1. Draw mission shape files in AgroSol. Follow all mission planning safety guidelines.
2. Calculate chemical ratio that will be used for the application.
3. Select safe mission speed and altitudes for this area. Follow all safety guidelines.
4. Charge all flight batteries, laptop and RC battery.
5. Confirm all required operational equipment is accounted for and in good condition.

Step 3: Spray Missions

1. Travel to spray area. Unload drone in a safe location as close as possible to application area. This will reduce ferry time and improve efficiency. Takeoff location selection is extremely important to safe and efficient missions. Location must be as close as possible and also in a spot where the drone's RTL path can be as safe and low altitude as possible.
2. Notify property owner that UAS operations will commence.
3. Begin spray procedures. Follow all preflight checks. Follow all UAS and chemical safety guidelines.
4. After completion, notify property owner. Rinse spray system and pack up. Follow safety guidelines for equipment transportation.

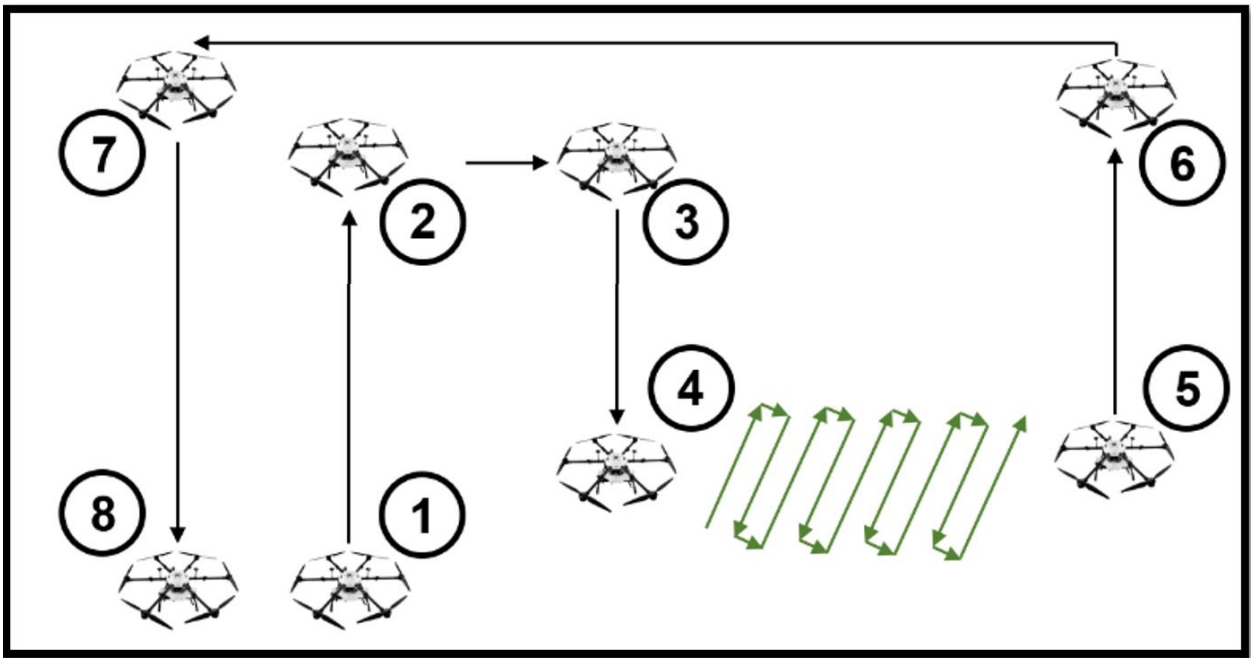
Step 4: Daily Maintenance

1. Follow Daily Maintenance Checklist (POST FLIGHT PROCEDURE)
2. Upload flight logs whenever possible.
3. Ensure equipment is stored safely. Follow storage safety guidelines.

Standard Flight Pattern

AgroDrone spray missions follow a standard flight pattern, as outlined by the 8 steps below.

1. Arm Motors. Take Off. Climb to **Ferry Altitude**
2. Reach Ferry-to-Field Altitude. Fly to Mission Spray Area at **Ferry Speed**
3. Reach Mission Spray Area. Descend to **Spray Altitude**
4. Reach Spray Altitude. Follow Mission Path & Spray Field at **Spray Speed**
5. Area Completed, Battery Depleted, Tank Empty, or Mission Paused by Operator: Stop, Climb to **RTL Altitude**
6. Reach RTL Altitude. Fly to Land Point at **RTL Speed**
7. Reach Land Point. Descend to Land
8. Land. Motors Disarm.



Ferry Altitude (ft): UAS Altitude during initial flight to spray/survey area (2-3)
Spray Altitude (ft): UAS Altitude during the spray/survey portion of the mission (4-5)
RTL Altitude (ft): UAS Altitude during RTL or Pause mode (6-7)

Ferry Speed (mph): UAS Speed while ferrying from takeoff to spray mission start (2-3)
Spray Speed (mph): UAS Speed during the entire mission (4-5)
RTL Speed (mph): UAS Speed during RTL or Pause mode (6-7)

First Flight

It is recommended to perform the first flights alongside a Hylio representative until the new owner is an adequately competent pilot. Follow this checklist, followed by the preflight checklist to ensure a safe and smooth first flight.

Environment	
1	Bring the drone and all tools to a safe and controlled environment
2	The location should be an open field with NO OBSTACLES anywhere nearby, in case of an unexpected mistake in control
3	No people should be present except the pilot and any person directly involved with assisting the operation
4	Move all vehicles well clear of the operation area
5	Make sure the weather is clear with low winds and will stay that way for the extent of the operation
Initial Setup	
1	Set up a table and chair for the ground station computer
2	Make sure you have power available for the ground station computer in case it runs low on battery. Take out the RC and set it on the table in case of emergency. Make sure the RC is fully charged
3	Set the drone up at least 20 yards away from the ground station
4	Make sure the drone is on level ground and the surrounding area is relatively level in case landing is not in exactly the same spot
5	Set up the arms and straighten out the propellers. Make sure the propellers are as straight as possible, this will reduce vibration on takeoff
6	Load the tank(s). Do not fill the tanks all the way, start off a little less than half full
7	Place the batteries in the frame and connect them to the drone
Mission	
1	Use the tracker to mark off a small area (around ½ acre) in the field far from any obstacle
2	Draw the mission boundary in AgroSol. Choose all mission settings carefully. Pay particular attention to altitude selections. Make sure the pump is enabled in the mission.
3	Proceed to follow the preflight checklist VERY CAREFULLY through takeoff
4	Fly many missions to gain practice and comfort with the system before you begin using the drone to spray chemicals.

AgroDrone: Pre-Flight Checklist

PIC _____ VO _____

Date _____ Drone _____

STEP 1:	**DRONE**	
	1: Arm	All arm elbow connectors secured in flight position
	2: Propeller	Remove bands/foam holders. Propellers tight and straight, inspect all for cracks and chips
	3: Spray	All tubes connected; No leaks; Tank(s) filled to desired fluid volume Nozzles firmly attached in correct orientation. Correct tips on nozzles Spray booms tightened and tubes fully inserted (110/116)
	4: Battery	Battery(s) fully charged and undamaged, plugged firmly into drone Battery strap tightened and slack tied off away from radar (110/116) Fully disconnect both used batteries before plugging in full batteries (122)
STEP 2:	**AGROSOL**	
	1: Connect	Plug in RFD to computer, connect to drone
	2: Pump	Arm Pump; Test pump (maintenance tab)
	3: Mission Settings (planning tab)	A. Safe Spray Altitude and Speed B. Mission Land Point at drone location C. Mission swath and buffer set as desired D. Mission & RTL lines do not cross obstacles E. Spray mode and rate set as desired. F. Save Mission Settings
	4: Upload	Upload Mission to drone. Confirm mission appears in Operations Tab
	5: Radar	Radar Altimeter shows good reading (operations tab)
	6: Battery	Full battery reading on AgroSol readout: 49.0 – 50.5 V
	7: Drone Auto and Manual Mode Settings	A. Safe Drone RTL Altitude and RTL Speed B. Safe Ferry Altitude and Ferry Speed C. Check following are set as desired: Empty tank RTL, Lost Link RTL, Area RTL Spray Descent Speed, Minimum Flowrate D. Save Drone Settings
STEP 3:	**LOCATION**	
	1: Takeoff & Land Area	A. Ground is flat and level B. No people or obstacles near drone
	2: Spray Area	A. Spray and Ferry/RTL area clear of all aircraft (manned or unmanned) B. No visible unmarked obstacles in spray area
	3: Weather	Follow flight envelope
STEP 4:	**ARM MOTORS & TAKEOFF**	
	1: Arm Motors	A. Arm Motors B. Wait for all motors to spin up C. No errors in AgroSol
	2: Takeoff	A. Click Take Off B. Drone climbs to correct Ferry altitude C. Drone flying smooth and stable D. No strange noises from motors
STEP 5:	**LAND**	
	1: Monitor Landing	Monitor drone as it descends to land, be ready to pause drone and adjust landing location if necessary

Manual Flight & RC Takeover

Fully Manual Flight

1	The drone must be in LOITER (manual) Flight Mode for manual flight. Always check manual flight settings in the AgroSol operations tab before flying in manual mode
2	To arm the drone, hold ONLY the throttle stick in the bottom right corner for 3 seconds. This will have the same effect as pressing “ARM” in AgroSol. The motors will begin to idle. If you do not proceed to takeoff in 5 seconds the drone will disarm itself
3	Once the motors are armed, raise the throttle stick above the center to around 75% of maximum. The drone will throttle up the motor speed to take off and continue climbing until the throttle stick is returned to 50%, where it will maintain altitude. If you simply let go of the throttle stick it will self-justify to 50%. Be careful not to push the throttle stick left or right when taking off, or it will yaw as it picks up off the ground, this can be dangerous
4	Press the right trigger to turn the pump on and off. The manual flight pump settings and manual flight max speed can be changed in the operations tab by clicking the settings cog on the drone panel
5	To land, make sure you are bringing the drone down over a level area. Slowly bring the throttle down below 50% and the drone will descend. Slowly descend until the drone is on the ground. Once the drone is on or very near the ground, bring the throttle down to 0%.
6	If you have trouble landing, you can always press the “LAND” button and the autopilot will take over and autonomously land in the current location. THIS IS HIGHLY RECOMMENDED. The drone typically will land autonomously much better than any pilot

Manual Takeover During Autonomous Flight

1	To take over manually during autonomous flight: If the RC is already turned on: - Press the D button to switch the drone into BRAKE mode, the drone will stop in place. Now press the A button to switch to LOITER mode. You now have manual control
2	To take over manually during autonomous flight: If the RC is not already turned on: - Turn on the RC. The RC may take as long as 20 seconds to boot up. As soon as it is booted up the RC immediately takes over the aircraft in LOITER mode. You now have manual control
3	Once you have manually taken over, the mission can only be resumed through AgroSol commands. You must click PAUSE in AgroSol, then you will be able to click RESUME, and the drone will resume its mission where it left off
4	At any time during manual control, AgroSol can be used to take back over and command a PAUSE, RTL, or LAND using the telemetry link. The drone will always listen to the last command received, either by the RC or by AgroSol.
5	If you are flying with RC, take over with AgroSol, then want to fly with RC again, to take over with the RC, you must make a CHANGE in flight mode. For example: If you use the RC to change to BRAKE mode, then press RTL on AgroSol, then press D again (BRAKE) on the RC, nothing will happen. You need to switch to a DIFFERENT flight mode for the drone to recognize the RC command.

Speed and Altitudes Selection

Flight Parameters and Terrain Considerations

Ferry Speed	Select a ferry speed as fast as you are comfortable flying in this area. This will reduce battery use, but be careful because as the drone flies faster you will have less time to react in an emergency situation.
RTL Speed	Use same logic as Ferry Speed to determine RTL speed.
Spray Speed	Whenever possible, use the toolbox speed calculator to determine flight speed as described.
Ferry Altitude	The ferry altitude is used when flying from the takeoff point to the mission area. You do not want this altitude to be higher than it needs to be, to save battery. The drone uses a large percentage of it's battery flying with a full tank. If you have a ferry altitude too high and a ferry distance too far, the drone may not have enough battery to spray out its full tank. You should position your take off location to allow for a low (but safe) ferry altitude. The drone will ferry through marked obstacles, start points and takeoff locations must be selected by the pilot to avoid this.
RTL Altitude	The RTL altitude is used when the drone is returning to land from the spray area. Set this altitude higher than any obstacles nearby the field, such as fences trees or vehicles. The drone WILL fly outside the marked spray area and through marked obstacles when at this altitude for RTL, and pause control. This altitude should be set as low as possible to reduce battery drain while remaining above obstacles. If obstacles are too high and it would not be feasible or legal to fly over them: rearrange your mission to avoid an RTL path through obstacles, or fly using the RTL denied advanced flight mode. This way the pilot can use the pause feature to ferry the drone home around obstacles.
Spray Altitude	The spray altitude is used during the spray portion of the mission. This should be selected based on crop height. Start with a high value, and decrease the altitude as you observe the flight response to your selected altitude value. You should spray 7 - 10 ft above most crops. Make sure this altitude is set to at least 2-3 feet more than the height of the crop. This way if there is an empty spot in the field, the drone will not descend in altitude to below the crop height (if this happens you are relying on the OA to stop you from crashing into the crop on the far side of the gap).
Swath Width	If spraying at 2 GPA, start with the value recommended in the chart above. Test with spray cards and functional spray tests whenever possible. This value is extremely important to a quality application and is affected by many different variables from wind, spray rate, altitude, chemical mix, particle size, even temperature and humidity.
Spray Angle	Select a spray angle to maximize straight lines in the mission, or to match crop rows. Longer straight lines will improve efficiency.
Terrain Considerations	For terrain with many obstacles or variable topography, fly higher and slower. You can decrease altitude and increase speed as you observe the

	drone's response to terrain variations. Fly along hillsides whenever possible as opposed to up and down hillsides. This is much more efficient and keeps the drone from constantly climbing up and down hills.
Spray Descent Speed	Spray descent speed has a range of 0.55 - 3.0 mph. This value determines the speed the drone descends when it detects a change in altitude with the rangefinder. If you want the drone to follow very closely DOWN steep hills, set this value higher (1.5-2.5). This may be desirable for vineyards or other applications with many hills that you want the drone to closely follow. If you do not want the drone to descend quickly, set this value lower (0.55 - 1.5). This may be desirable for flat fields of row crops where you do not want the drone to quickly lose altitude when flying over a low spot in the crop.

Tips and Tricks

Safe Missions

Almost all drone crashes are caused by unsafe missions:

1. Ferry altitude too low or path crosses an obstacle
2. RTL altitude too low or path crosses an obstacle
3. Spray altitude too low for terrain and drone runs in to crop

In all of these cases, OA may save the drone, but it has blind spots. OA should not be relied on to avoid crashes, safe mission planning should be relied on to avoid crashes. Follow the guidelines in the previous chart as well as the following list to avoid these unsafe missions.

1. Always double check that the drone has a safe path at the ferry altitude from the takeoff point to the mission start point. The drone will not avoid marked obstacles along this path.
2. Assume the drone could RTL at any point in the mission for various reasons. Visualize the path from any point in the mission back to the land point. Select an RTL altitude that would result in a safe RTL from any point in this mission. The drone WILL NOT avoid marked obstacles during RTL, it will proceed straight to the land point. If it is not feasible or legal to RTL above some marked obstacles (windmills/large power lines for example): you have two options. 1) Cut your mission into one side and the other side of this obstacle. 2) use the "RTL Denied" advanced flight mode. This way the drone will stop and wait for a command instead of RTL, and the pilot can safely direct the drone around an obstacle and back to the land point themselves.
3. Select a spray altitude 2-3 feet higher than the crop height. Select a value even higher for terrain with steep hills.

Efficient Missions

Avoid ferrying long distances. Set a fast ferry speed to reduce ferry time. The drone uses the majority of its battery when fully loaded. It is often more efficient to RTL a drone early when it is close to its land point along a mission, than it would be to wait for it to spray out the rest of its tank and RTL from far away. If you RTL from far away, then you will have to ferry back out there with a full tank. This uses more battery and takes time away from spraying.

Blocking Radars

OA Radars:

Be careful not to block the OA radars with the spray tubes or battery belt. If anything swings in front of these the drone will stop suddenly without warning. Always check that the OA radars will stay free from obstruction during the flight.

Altimeter Radar:

Be very careful not to bock the downward facing radar, this radar has a wider angle of view than many people expect. If there is an obstruction, then the drone will take off and begin to climb until the pilot intervenes. The radar will show an output on AgroSol as if it is still on the ground, as it continues to climb. **If you notice the drone climbing above the expected altitude and continues to climb, immediately activate the RC and manually land the aircraft.** This can occur in most commonly on the AG-122 model if the user re-routes some of the tubing below the flowmeters.

Error: No Terrain Data

This error displays when the radar altimeter outputs a 0.00 reading to the flight controller. This tricks the flight controller into thinking the radar is not working. Occasionally this can happen if the drone is placed in long grass that crowds the radar in a certain way. The altimeter radar is not calibrated for this sort of close range. If this happens, try picking up the drone and setting it back down. Typically, this will give the radar some non-zero reading and the flight controller will allow you to take off.

Emergency Action

Your 5 main options for emergency action are RTL, Land, Brake/Pause, Manual Takeover, and Motor Kill. There are different situations where each of these may be the best option. Some of these situations are listed below.

1. If the drone is flying well, but is headed in an unexpected direction after takeoff, command RTL, either through AgroSol or the RC.
2. If the drone is flying well, but is headed in an unexpected direction during RTL, either Brake/Pause, or Manual Takeover, whichever you are most comfortable with.
3. If the drone is not flying well, press land. If the drone appears unable to land itself safely, Manual Takeover and do your best to take it down quickly
4. If the land point has become unsafe, press Pause or Manual Takeover, and bring it to a safe land position

Some of these situations could happen due to poor mission creation, others could only happen in the case of damage or sensor failure. It is important to understand what your options for emergency action are, and what they will do. As the PIC you must know these commands with confidence and how to activate them.

Safety Mindset

When spraying large acreage, it is easy to become complacent when in regards to safety. When the drone is flying dozens of missions over and over, it can begin to feel repetitive. The PIC must always remain vigilant, following all safety protocols and checklists, ready to intervene at any moment. As a new pilot, it is important to start slow and safe. Take the time to ensure each mission is thoroughly planned. As mentioned above, almost all crashes are caused during the mission planning phase. Start with slow flight speeds and high altitudes. Move on to more advanced operations as you gain more experience with the drone.

Safety Guidelines

Large Agricultural UAS can be extremely dangerous if used improperly. The following guidelines and limitations must be followed to ensure safe and effective operation of the AgroDrone.

Flight Envelope

Altitude	0 – 350 ft AGL
Speed	0 – 25 mph
Precipitation	None – Light Rain
Temperature	40 – 100 deg F
Wind	0 – 20 mph
Battery Voltage	50.4 V: Fully Charged 42.8 V: Initiate Automatic RTL 41.5 V: Initiate Emergency Land 40.0 V: Motor Power Cut

Field Marking

1	Place flags 7 yards away from obstacles along field edges, to account for the worst GPS inaccuracy
2	All obstacles must be marked 20 feet larger than actual size The GPS Tracker drops “Obstacle” markers in AgroSol that force the flight path to avoid that area during the spray mission (NOT RTL or Ferry). AgroSol allows the user to select an obstacle radius. Set this radius 20 ft larger than the radius of the obstacle
3	Drop boundary-flags every 100 ft when marking along a straight field edge.
4	Drop boundary-flags every 25 ft when marking along a curved field edge.
5	Always mark ALL obstacles within a field. Do not rely on obstacle avoidance.
6	Always mark field edges when spraying a field with many trees, power lines, or other obstacles near the field edge.

Mission Settings

1	Before drawing a mission boundary, the field must be surveyed to check for obstacles within or around the mission area. Fields with extreme altitude differentials should not be sprayed. Fields with an extreme number of in-field obstacles should not be sprayed.
2	Mission boundaries should never be drawn outside marked boundary-flags. (if the field was marked with GPS Tracker)
3	RTL height must be at least 15 feet above all obstacles near the mission area. Should the UAS automatically RTL at any point in the mission, this RTL altitude must be high enough for the UAS to safely return home and land.
4	Land Points must be set with a 10 ft radius of flat and clear ground. If operating multiple UAS: All land points must be 25 ft apart.
5	Always adjust spray altitude with consideration for topography and crop height.
6	Always select mission speeds and altitudes within the Flight Envelope.
7	Select flight speed based on topography and spray settings. Fly higher and slower in hilly terrain. Fly slower for high flowrates. Use the AgroSol Toolbox Speed Calculator to determine max speed when spraying.

Storage & Transport

1	Always store all UAS, Batteries, and Charging Equipment between 50 – 85 deg F. For long term storage, all hardware should be stored in a climate-controlled environment.
2	A fire extinguisher must always be available nearby batteries in transport or storage.
3	Always strap down UAS during transport to avoid damage.
4	Batteries in long term storage must be at a storage charge voltage level (46.2 V).
5	Spray System must be extremely clean before long term storage to avoid damage.
6	Cycle batteries once every 4 months to ensure longevity (charge/discharge to storage).

UAS Operation

1	Never operate UAS outside the flight envelope.
2	If the UAS is in an uncontrolled climb for any reason, press LAND. This will force the UAS to ignore all altitude sensors and begin decent. If this does not work, take over manual control.
3	Always follow the preflight checklist.
4	Always verbally announce takeoff and landing.
5	Always follow applicable regulations at the location of operation.
6	Never fly over people, buildings, or vehicles unless absolutely necessary.
7	Always monitor the Ground Control Station for errors or potential problems.
8	Do not stand within 20 ft of the UAS during takeoff or landing.
9	Never fly under the influence of alcohol or drugs.
10	Always be aware of the application area airspace and surrounding environment.

Battery Safety

1	Batteries should be fully charged before each use
2	Only connect two batteries to a drone that are the same voltage (AG-122 only)
3	Label and keep batteries in pairs (AG-122 only). This will ensure that batteries connected to a drone will be the same voltage, and that they will wear down at the same rate. This keeps charge and discharge times similar.
4	Be aware that LiPo batteries can be extremely dangerous if not handled properly
5	Keep rubber battery connector cap over the battery cable at all times unless the battery is in use
6	Be careful not to short battery leads when plugging/unplugging from UAS
7	Always store and transport batteries in fire-proof lipo safe bags. Be careful not to get water in the balance cable port on the batteries.

Chemicals and Environment

1	Always wear appropriate personal protective equipment when handling chemicals.
2	Always read pesticide label before use. The label is the law.
3	Thoroughly clean spray system when switching chemicals. Chemical residue can get caught in the tube connectors and contaminate the following application.
4	Never dump leftover chemicals in or near the application area. Locate a safe deposit for chemical disposal to use.
5	Do not mix chemicals for application without advanced knowledge of pesticide application. Some chemicals may be extremely dangerous when mixed improperly.
6	Always be aware of potential drift from the application area. Make sure all people and animals stay clear of the application area for the label designated time period.

Multi-UAS Control

1	Take Off and Land Points of multiple UAS must be at least 25 ft apart. (AgroSol Enforced)
2	Only take off and land 1 UAS at a time. Stagger take off and landings so Pilot can focus on drones actively taking off or landing.
3	Always be aware which drone is which when in flight or on the ground.
4	Avoid giving UAS “crossing” missions. Each UAS should be the closest UAS to its own mission area. This will help the UAS keep from crossing paths in the air.
5	UAS RTL alts and Ferry Alts cannot be within 10 feet of each other to avoid collision. (AgroSol Enforced)
6	If using 2 UAS on the same field, start them on similar sides of the field to avoid collision.